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Physical characteristics and chemical composition of local rabbit meat and Hycole-local crosses fed different levels of feeding

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ABSTRACT

The demand for rabbit meat as an alternative source of animal protein is increasing along with population growth and public nutritional awareness. This study aimed to evaluate the effect of feeding levels on the physical and chemical quality of local rabbit meat and the results of the Hycole × Local cross. A total of 36 male rabbits (18 local and 18 cross) were used in a randomized block design with three feed levels (6%, 7.5%, and 9%) and six replications. The parameters observed included hot and cold carcass pH, moisture content, ash, meat color, cooking loss, water holding capacity, protein content, fat content, and tenderness. The results showed that most of the physical characteristics and chemical composition parameters were not significantly different ($P>0.05$) between local rabbits and the Hycole × Local cross, and between feed levels, except for cooking loss and tenderness ($P<0.05$). The cooking loss values of meat in this study were found to be 17.10±5.23 and 13.75±4.02%; while the tenderness value was 1.48±0.79 and 2.30±1.42 kg/cm^2, respectively, for local rabbits and Hycole x local crosses. The cooking loss and tenderness values of rabbit meat fed 9% of body weight were higher than those fed 6 and 7% of body weight, namely 18.66±3.93% and 2.52±1.13 kg/cm^2, compared to 15.42±1.06% and 1.89±0.41 kg/cm^2. Based on these findings, it can be concluded that increasing the amount of feed up to 9% of body weight can be done for both local rabbits and Hycole x local crosses, as long as it improves productivity.

Introduction

The demand for animal-based foods, particularly meat, continues to rise in line with population growth, increased public awareness of nutrition, and economic expansion. One alternative source of animal protein that is increasingly being developed is rabbits, due to their rapid growth, high feed efficiency, and adaptability to tropical environments. Rabbit meat is classified as white meat, boasting a tender texture, high protein content, and low levels of fat and cholesterol. Rabbit farming is also relatively easy to operate, does not require extensive land, and has a short production cycle. Native rabbits are a common breed of rabbit bred in Indonesia due to their ability to survive in tropical environments and efficiently utilize local feed. However, the productivity of native rabbits remains relatively low, both in terms of growth and carcass quality, necessitating efforts to optimize rabbit meat production (Setiaji et al., 2024). One strategy is through crossbreeding with superior meat breeds such as Hycole, which is known for its rapid growth and high carcass yield. Furthermore, the level of feeding is also a crucial factor in supporting growth performance and meat quality.

Rabbit meat quality can be evaluated through physical and chemical parameters that reflect the quality and economic value of the meat, such as pH, moisture content, fat content, meat color, and texture. These parameters are influenced by various factors, including breed, sex, age, feed management, and rearing environment. Several studies have shown that a combination of superior genetics and proper nutritional management can improve carcass performance and meat quality (Lawrie and Ledward, 2006; Brahmantiyo *et al*., 2018). However, studies on the physical and chemical quality of meat from rabbits crossbred with local and Hycole rabbits are still limited, especially those examining the effect of different feed levels. Therefore, this study aimed to evaluate the effect of feed levels on the physical and chemical quality of meat from local and Hycole rabbits crossbred with Hycole rabbits. The results of this study are expected to provide valuable scientific insights for developing an efficient, genetically superior, and sustainable meat rabbit production system in Indonesia.

Materials and methods

This study was conducted with a randomized block design involving 2 groups of rabbit breeds, 3 treatments of feeding levels and 6 replications. The material used in this study consisted of 36 male rabbits, comprising 18 local rabbits and 18 Hycole-local crossbred rabbits. The initial body weight of the experimental rabbits ranged from 854.39±46.96 g for the local rabbits and 863.4±42.92 g for the Hycole-local crossbred rabbits. The feed tested was a complete feed in pellet form. The feed contains CP= 17.85% and ME = 3823,08 Kcal/kg (Table 1).

Table 1. Feed ingredients and nutrient composition.

Feed Ingredients[1]	Composition	Nutrient Composition					
		DM (%)	Ash (%)	CP (%)	EE (%)	CF (%)	GE (Kcal)
Corn	3	2.57	0.04	0.32	0.13	0.03	132,03
Pollard	22	19.12	0.97	3.46	1.14	2.26	885,94
Coconut meal	2	1.82	0.19	0.37	0.24	0.14	87,06
Soybean meal	8	7.14	0.48	3.21	0.13	0.26	355,04
Hay Tridax Procumbens	32	27.12	0.7	5.4	0.26	5.71	1149,44
Corn gluten feed	26	22.32	2.28	4.39	0.6	3.69	290,57
Molasses	7	5.39	0.54	0.7	0.32	0.06	923,00
Total	100	85.49	5.19	17.85	2.8	12.15	3823,08

DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; ME: Metabolizable Energy; CGF: Corn Gluten Feed

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This research was conducted in 4 stages, namely (1) preparation (30 days), including preparation of cages, equipment, livestock and feed, (2) adaptation (10 days), livestock adaptation period to battery cages (30×50×40 cm, temperature 20-25°C, RH±70%) and feed treatment, (3) preliminary phase (4 days), in this phase measuring initial weight and providing treatment feed, and (4) treatment (90 days), providing treatment feed according to the research design, providing drinking water ad-libitum and slaughtering livestock at the end of the research period. The parameters observed in this study included the physical and chemical quality of meat, as determined by the AOAC method (1980); Apriyanto *et al*. (1989); Hopkins *et al*. (2011); Santos *et al*. (2022), and Warastomo *et al*. (2021). The research data were analyzed using ANOVA and Duncan's multiple range test according to Sudjana's instructions (1982).

Results

The results of the study showed that local rabbits produced meat with better physical quality than Hycole x local cross rabbits, while chemically, both breeds produced the same quality. In addition, the results of this study also show that increasing the amount of feed to 9% of body weight only affected the physical quality but did not affect the chemical quality of meat produced by either local rabbits or Hycole x local cross rabbits. Differences in the physical quality of meat between the two rabbit breeds were only detected in the cooking loss and tenderness variables, local rabbit meat had a higher cooking loss value (P <0.05) and lower tenderness (P <0.05) than Hycole x local cross rabbit meat. Other physical quality variables of meat were found to be no different (P>0.05) between local breeds and Hycole x local cross rabbits. The cooking loss value of local rabbit meat and Hycole x local crosses fed 9% feed was found to be higher (P<0.05) compared to those fed 6 and 7.5% of body weight. In contrast, the tenderness value was found to be the opposite; local rabbits and Hycole x local crosses fed 9% of their body weight produced meat with a higher tenderness value than those fed 6% and 7% of their body weight. Increasing the amount of feed given to 9% of body weight mainly affected only the cooking loss and tenderness parameters. The differences in the values of cooking loss and tenderness variables in meat produced by both rabbit breeds fed 9% of body weight did not have implications for overall meat quality, because the differences were only found in a small portion of the quality variables. In addition, the magnitude of the changes was relatively small, not affecting the overall quality.

Discussion

Physical test results showed that only cooking loss and tenderness parameters showed significant differences, while other variables, such as hot and cold carcass pH, meat color (L, a, b*), and water holding capacity, showed no significant differences (P>0.05) between treatments or breeds. Lower cooking loss values (P<0.05) were found in the Hycole x local crossbred rabbits, while lower tenderness values were found in the local rabbits. Both rabbit breeds showed a positive response (P<0.05) only to a 9% increase in body weight in feed intake. This finding indicates that the meat from this study was of good physical quality. An increase in feed intake of 9% of body weight improved the physical quality of both breeds, only in terms of cooking loss and tenderness. This finding implies the importance of considering the minimum feeding limits that can be applied to improve the physical quality of meat produced by both local and Hycole x local crossbred rabbits.

Local rabbit meat and Hycole x local crosses generally have similar physical characteristics (P>0.05) in color parameters (L*, a*, b*), meat pH (hot and cold carcasses), and water holding capacity (WHC) (Table 2); however, in terms of cooking loss and tenderness, significant differences were identified (P<0.05), both between breeds and between treatments. The meat color of the results of this study was found to tend to be bright yellowish (L*= 53.43±0.56; a*= 5.32±0.12; and b* = 4.76±0.22). Based on the visual characteristics of rabbit meat according to Cullere *et al*. (2018). The L* value (brightness level) has a range of values 0 (black) to white (100), the higher the L* value, the brighter. The a* value of red color intensity ranges from green (-60) to red (+60), the higher the redder the meat color. b* Value The level of yellowness ranges from blue (-60) to yellow (+60), the higher the b* value the more yellow the meat color. The pH value of post-slaughter carcass meat measured after 8 hours of aging remained on average above 5, namely 6.75±0.09 (HCW) and 5.88±0.001 (CCW). This pH value is still within the normal range, according to Liste *et al*. (2008), namely 5.76–5.93, which indicates that glycolysis during the aging period is functioning properly. The water-holding capacity value of the meat from this study was also recorded to be within the normal range, namely 84.10±1.59%, which indicates the meat's capacity to retain fluids well (Belichovska *et al*., 2017), resulting in a juicier and more tender product when cooked. However, the water-holding capacity value of the meat from this study is still lower than the report by Hermawan

Table 2. Physical characteristics of meat from local rabbits and Hycole-local crossbreed rabbits with three levels of feed.

	Variable / Breed[2]	Treatment			Average
		T0	T1	T2	
1	pH Hot Carcass				
	Local	6.83±0.72	7.16±0.54	6.55±0.34	6.85±0.53
	Hycole×Local	6.58±0.37	6.79±0.57	6.60±0.46	6.65±0.46
	Average	6.70±0.54	6.97±0.56	6.58±0.40	6.75±0.09
2	pH Cold Carcass				
	Local	6.03±0.74	6.20±0.44	5.73±0.48	5.99±0.55
	Hycole×Local	5.36±0.42	6.02±0.57	5.95±0.52	5.78±0.50
	Average	5.84±0.58	6.11±0.51	5.84±0.50	5.88±0.001
3	L*				
	Local	53.90±2.94	53.35±2.29	51.00±4.81	52.75±3.35
	Hycole×Local	52.88±1.55	55.82±3.01	53.64±2.97	54.11±2.51
	Average	53.39±2.24	54.59±2.65	52.32±3.89	53.43±0.56
4	a*				
	Local	5.03±2.23	4.84±1.64	6.03±3.26	5.30±2.38
	Hycole×Local	5.48±1.64	5.27±2.99	5.29±2.23	5.34±2.29
	Average	5.26±1.94	5.05±2.31	5.66±2.74	5.32±0.12
5	b*				
	Local	4.35±1.76	4.11±1.46	4.21±1.49	4.22±1.57
	Hycole×Local	4.71±2.06	6.29±1.42	4.90±1.68	5.30±1.72
	Average	4.53±1.91	5.20±1.44	4.55±1.58	4.76±0.22
6	Cooking Loss (%)				
	Local	14.90±5.41	15.38±6.06	21.03±4.24	17.10±5.23[x]
	Hycole×Local	12.10±3.89	12.85±4.53	16.29±3.63	13.75±4.02[x]
	Average	13.50±4.65[a]	14.12±5.30[a]	18.66±3.93[b]	15.42±1.06
7	Water Holding Capacity (WHC) (%)				
	Local	81.91±4.89	81.76±7.66	84.95±5.35	82.87±5.96
	Hycole×Local	84.22±3.41	84.11±4.62	87.62±1.79	85.32±3.27
	Average	83.07±4.15	82.94±6.14	86.29±3.57	84.10±1.59
8	Tenderness (kg/cm²)				
	Local	1.24±0.98	1.15±0.61	2.06±0.77	1.48±0.79[x]
	Hycole×Local	1.91±1.00	2.02±1.75	2.98±1.49	2.30±1.42[y]
	Average	1.57±0.99[a]	1.59±1.18[a]	2.52±1.13[b]	1.89±0.41

et al. (2021), namely 93.31±13.19, but still within the normal range for good-quality meat.

Table 3. Chemical composition of meat from local rabbits and Hycole-local crossbreed rabbits with three levels of feed.

Variable / Breed[3]	Treatment			Average
	T0	T1	T2	
1 Moisture (%)				
Local	75.28±1.71	73.21±5.49	72.09±3.15	73.53±3.45
Hycole×Local	73.23±3.10	73.36±1.70	73.88±2.67	73.49±2.49
Average	74.26±2.41	73.28±3.60	72.98±2.91	73.51±0.98
2 Ash (%)				
Local	0.96±0.01	0.99±0.06	0.99±0.05	0.98±0.04
Hycole×Local	0.99±0.04	1.00±0.06	1.02±0.06	1.00±0.05
Average	0.98±0.02	1.00±0.06	1.00±0.05	0.99±0.005
3 Protein (%)				
Local	19.57±1.39	19.51±1.20	20.82±1.19	19.97±1.26
Hycole×Local	19.69±1.29	20.26±1.12	19.76±0.68	19.90±1.03
Average	19.63±1.34	19.88±1.16	20.29±0.94	19.93±0.22
4 Fat (%)				
Local	3.16±1.55	3.44±1.60	2.74±1.40	3.11±1.52
Hycole×Local	2.00±1.34	2.70±0.85	3.02±1.30	2.57±1.16
Average	2.58±1.44	3.07±1.23	2.88±1.35	2.84±0.19

Two other physical quality variables, namely cooking loss and tenderness, showed significant differences ($P<0.05$) between treatments in the two rabbit breeds studied. Cooking loss of local rabbit meat in this study was recorded as greater ($P<0.05$) than that of the Hycole x local crossbred rabbit meat, respectively at 17.10±5.23 and 13.75±4.02%. Conversely, the tenderness value of local rabbit meat was recorded as lower ($P<0.05$) than that of the Hycole x local crossbred rabbit meat, respectively at 1.48±0.79 and 2.30±1.42 kg/cm^2. Increasing the amount of feed given at the level of 9% of body weight had a negative impact on cooking loss and tenderness in both local rabbits and Hycole x local crosses; each of these parameters values increased to 18.66±3.93% and 2.52 1.13 kg/cm^2. Although both parameter values worsened, meat with cooking loss and tenderness values above was still included in the good category, because according to Lawrie's criteria (2003) meat with cooking loss of 15-40% can still maintain liquid levels during cooking, while meat with tenderness values <3.5 kg/cm^2 was still included in the very tender category (Kozioł *et al*., 2016). Overall, increasing feed from 6% to 9% of body weight in local rabbits and Hycole x local crosses was not followed by changes in the physical characteristics of the meat produced, except for an increase in cooking loss and tenderness values.

The findings of the response of local rabbits and Hycoloe x local crosses to an increase in the amount of feed given by 9% of body weight, an increase in cooking loss and tenderness, showed that the increase in feed only affects some of the quality variables of the meat produced. Rabbit meat belongs to the white meat group (L* 52.7-55.5; b* 6.5-7.5) (Castrica *et al*., 2024) and can still be maintained at L* 53.43±0.56 and b* 4.76±0.22. The ultimate pH value of rabbit meat is in the range of 5.6 to 6.8 (Liste *et al*., 2009) and can still be maintained at 5.88±0.001. The cooking loss and tenderness values of local rabbits and Hycole x local crossbreds fed 9% of their body weight, although higher than those fed 6 and 7.5% of their body weight, were still tolerable for maintaining good meat quality. According to theory, good-quality rabbit meat has a cooking loss of 30.22-39.15% (Hernández *et al*., 1998; Bosco *et al*., 2001; Yalçin *et al*., 2006; and Omojola, 2007), and good tenderness is around 3.57 kg/cm^2 (Ariño *et al*., 2006). In this study, feeding at 9% of body weight increased these two variables to 18.66±3.93% and 2.52±1.13 kg/cm^2, respectively. Based on the above explanation, it can be concluded that the increase in cooking loss and tenderness values due to a 9% increase in feed intake is still tolerable.

The higher cooking loss value in meat produced by both rabbit breeds fed 9% compared to those fed 6% and 7.5% of body weight in this study is closely related to the high water and dissolved materials released due to heating. Rabbits fed 9% of body weight or 3% above the basic living requirements will deposit excess feed protein in muscle growth. Rabbit meat contains 75.84% water in which various compounds (protein, minerals) are dissolved and 2.3% fat (Fadlilah *et al*., 2019). Postnatal muscle growth occurs largely through the process of hypertrophy, or the enlargement of muscle fibers (Schoenfeld, 2010). Approximately 30% of this growth is in the form of sarcoplasm/myoglobin, which, when heated, is more easily loosed compared to structural proteins or myofibrils (Hord *et al*., 2024). The process of heating meat can cause changes in its structure (protein denaturation), as well as the loss of water and dissolved substances (Pang *et al*., 2020). Thus, it is understandable that rabbits fed 30% above their basic living needs in this study produced meat that had a greater cooking loss value compared to those fed the same or slightly above their basic living needs.

The increased tenderness of rabbit meat fed 9% of body weight is related to muscle fiber development, fat deposition, and connective tissue composition (Tholen *et al*, 2024). Feeding 9% of body weight in rabbits has exceeded 30% above the basic living needs (Lebas, 2013), so that excess nutrients (protein and energy) in the feed consumed will be used for growth, considering the rabbit's age is still relatively young (2-4 months), so the excess feed will be accumulated more in muscle tissue than in the form of fat.

If the physical quality of the meat is not the primary objective, increasing the feed intake by up to 9% of body weight in local rabbits and Hycole x local crosses can be done without causing a significant effect on most physical parameters of the meat produced, such as pH and water holding capacity. These results indicate that increasing feed intake can be utilized efficiently without affecting the basic physical quality of the meat. However, there were significant differences ($P < 0.05$) between the two breeds and feed level treatments in cooking loss and tenderness values. Local rabbits had higher cooking loss values (17.10±5.23) than crossbred rabbits (13.75±4.02), and lower tenderness values (1.48±0.79) than crossbred rabbits (2.30±1.42). This means that although local rabbit meat is more tender, it tends to lose more fluid during the cooking process. This characteristic remains relevant to the public's preference for a soft, chewable meat texture. Thus, the selection of rabbit species and the level of feeding are crucial factors in producing high-quality meat that meets the community's needs.

The meat of local rabbits and the local crossbred Hycole rabbits generally showed similarities in chemical characteristics ($P>0.05$) across all parameters, including moisture, ash, protein, and fat content (Table 3). The average moisture content of meat in this study was 73.51±0.98%, which is within the normal range of 68–80% and close to the ideal level of 75% according to Forrest *et al.* (1975). The ash content of rabbit meat in this study was recorded at 0.99±0.005%, which is still close to the ideal level of around 1%, or within the range of 1.06–1.19% reported by Brahmantiyo *et al*. (2014). The average protein content of rabbit meat was found to be 19.93±0.22% and was within the ideal range of 16–22% or close to 20.8% as stated by Bizkova and Turnova (2010). The fat content of the meat from the two rabbit breeds studied was found to be 2.84±0.19%, which is still within the normal range of 1.5–13% according to Forrest *et al.* (1975). These findings indicate that increasing the level of feeding from 6% to 9% of body weight did not have a significant effect on the chemical composition of the meat, and that both local rabbits and the Hycole x local crossbreeds.

The finding that increasing the feeding rate from 6% to 9% of body

weight had no significant effect (P > 0.05) on the chemical composition of meat in local rabbits and Hycole x local crosses indicates that both rabbit breeds can still maintain the composition of the meat produced effectively. The water content of the meat in this study was within the normal physiological range as reported by Forrest *et al.* (1975) and Belichovska *et al*. (2017). This indicates that muscle hydration was well maintained in all treatments. The ash content of the meat was found to be close to the ideal of around 1%, or within the range of 1.06–1.19%, according to Brahmantiyo *et al*. (2014). This ash content finding reflects the stability of mineral content in muscle tissue, which according to Pla *et al.* (1996) is more influenced by muscle location and tissue type than genetic factors or feed composition. The protein content of the meat was found to be within the ideal range of 16–22%, which is close to the 20.8% reported by Bizkova and Turnova (2010). This indicates that the nutritional quality of the meat from both breeds is considered good. Meanwhile, the fat content of the meat shows a range in accordance with the normal standard of 1.5–13% according to Forrest *et al.* (1975). Overall, the stability of these chemical parameters suggests that both rabbit breeds studied can maintain the quality of their meat production even as their feed intake increases by up to 9% of their body weight.

Conclusion

Increasing the feed level (6%, 7.5%, and 9% of body weight) generally has no effect on the physical characteristics and chemical composition of meat in local rabbits or Hycole x local crosses. A decrease in characteristics occurs in cooking loss and tenderness; however, the level of decrease did not impact overall quality. Therefore, increasing the amount of feed given to 9% of body weight in both rabbit breeds can be recommended, provided it improves productivity.

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Conflict of interest

The authors have no conflict of interest to declare.

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